The Impact of Variable DC-Bus Voltage Control on the Inverter Lifetime in Electric Vehicle Applications

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ABSTRACT

The reliability of the power converters in electric vehicle applications has been a great concern. As most power converters are not designed with redundancy, a malfunction of any component in the converter may prevent the vehicle to operate. Thermal cycling of the power devices is one of the main causes of failure in the power converter. Since the temperature and power losses of a power device are proportional, thermal cycling can be reduced by controlling one of the loss-related variables, such as the dc-bus voltage. For instance, variable dc-bus voltage control which adjusts the dc-bus voltage to the required motor stator voltage, has been widely investigated in the literature as an effective approach to reduce inverter power losses. In this paper, the effectiveness of this strategy in comparison with constant dc-bus voltage control is analyzed in terms of lifetime improvement. The analysis is carried out under Artemis urban and US06 driving cycles, which are used to obtain the thermal loading of the inverter power devices. Then, a lifetime model that explores the link between the thermal loading and lifetime consumption is presented. The performance analysis is validated through MATLAB Simulink which reveals that, variable dc-bus voltage control has the ability to improve the lifetime of the inverter by a factor of 5.06 and 3.43 under Artemis urban and US06 driving cycles, respectively.

KEYWORDS: Inverter, power device, reliability, lifetime, variable dc-bus voltage control (VVC), thermal cycling

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